Dust RT in high-z simulated galaxies

Post-processing dust radiative transfer in HELLO simulations

Mitali Damle[1]

[1] *New York University Abu Dhabi*

mitali.damle@nyu.edu

Introduction

- Galactic observations, especially photometric and spectroscopic, are underlined by dust absorption and re-emission to varying degrees. Dust grains in the star-forming regions of a galaxy absorb some of the UV radiation from young stars and reprocess it to higher wavelengths. This results in changes in the galaxy colors, spectral energy distributions (SEDs) as well as the overall energy balance of the system.
- By combining the abilities of the **SKIRT** radiative transfer code with data from the HELLO (**H**igh-z **E**volution of **L**arge and **L**uminous **O**bjects) simulations, I aim to perform post-processing calculations for dust on a combined statistical sample of more than **800 high-z galaxies at z = 2.0 and 3.6**.
- I obtain mock UV fluxes for the simulated sample, aiming to ultimately build a **UV luminosity function** (UVLF) for HELLO simulations.

HELLO Simulations

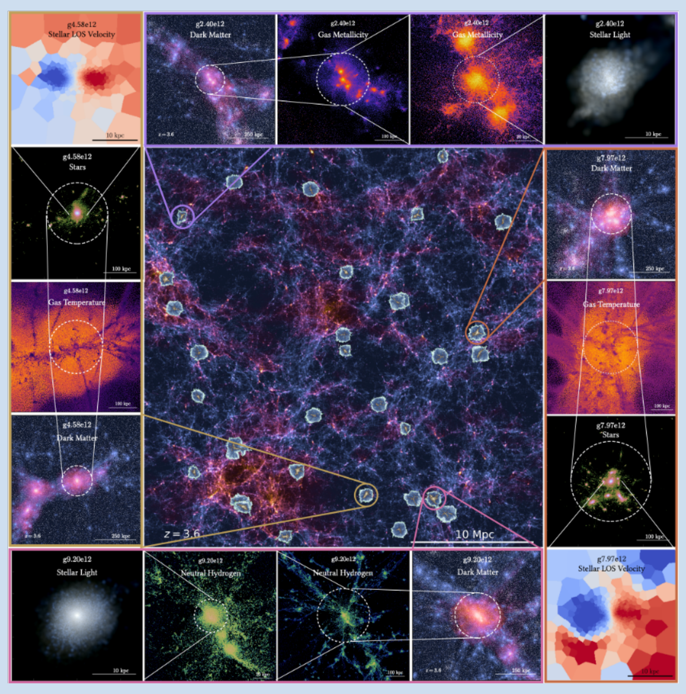

Fig. 1: *Overview of HELLO simulations*

⇒ Zoom-in suite of simulated **Milky-Way-mass galaxies**.
⇒ Successor of the z=0 **NIHAO** simulations, with the same gravity but improved hydrodynamics treatment.
⇒ Primary dataset has total 32 galaxies: **17** galaxies at z = **2.0** and **15** galaxies at z = **3.6**; but the zoom-in fields also have many less-massive galaxies.

Sample Curation

We use the following criteria for curating our galaxy sample:

- Galaxies with a **minimum of 100 stellar particles**.
- Galaxies with $\mathbf{M}_{dm} > \mathbf{10^8}\ \mathbf{M}_\odot$.
- Galaxies with $\frac{\mathbf{M}_*}{\mathbf{M}_h} > \mathbf{0.00025}$.

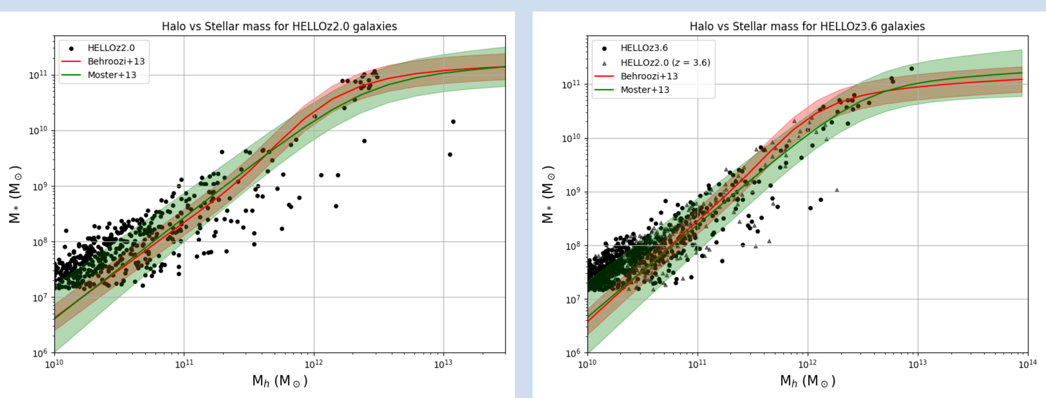

Fig. 2: *M_*-M_h relation for our HELLO sample (black points). In shaded green (red) are the standard M_*-M_h relations from Moster+13 (Behroozi+13.)*

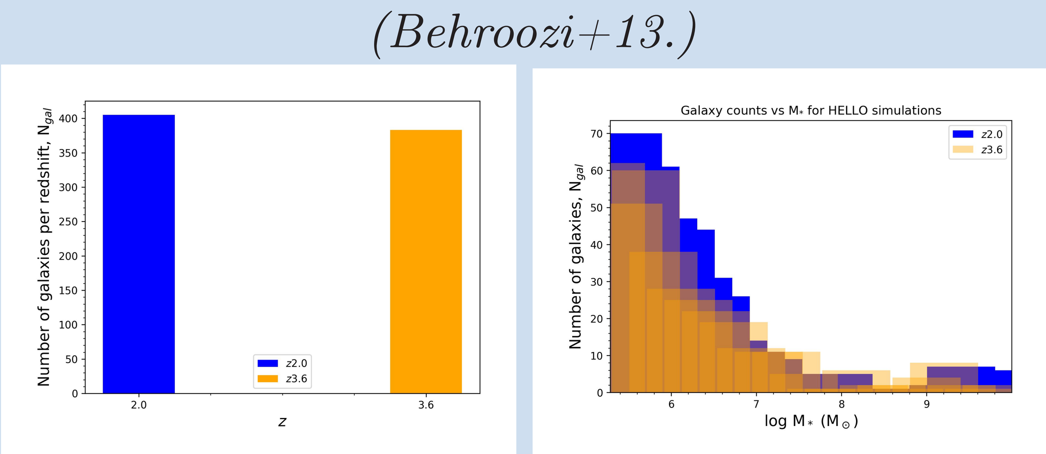

Fig. 3: *Galaxy counts for our HELLO sample as a function of z and M_*. Each redshift bin contains ~ 400 galaxies.*

Implementing dust RT via SKIRT code

SKIRT: **S**tellar **K**inematics **I**ncluding **R**adiative **T**ransfer (Camps & Baes 2020)
⇒ Simulates key RT processes like dust absorption, scattering and emission.
⇒ Emulates different geometries, radiation sources, underlying grids, detectors, etc.
⇒ Adaptable to a variety of simulation codes.
⇒ Extremely modular nature makes it highly customizable to specific use cases.

ASTRODEEP survey: Comparing with JWST observations

James Webb Space Telescope (JWST) has superlative data, especially in the HELLO simulations target redshift range, $2 < z < 4$.
⇒ ASTRODEEP-JWST is a collection of data from eight JWST NIRCam observational programs targeting Abell 2744, EGS, COSMOS, UDS, Goods North and South fields.
⇒ ASTRODEEP has ~900 (~250) galaxies in range $1.9 < z < 2.1$ ($3.5 < z < 3.7$) that have spectroscopic redshifts.

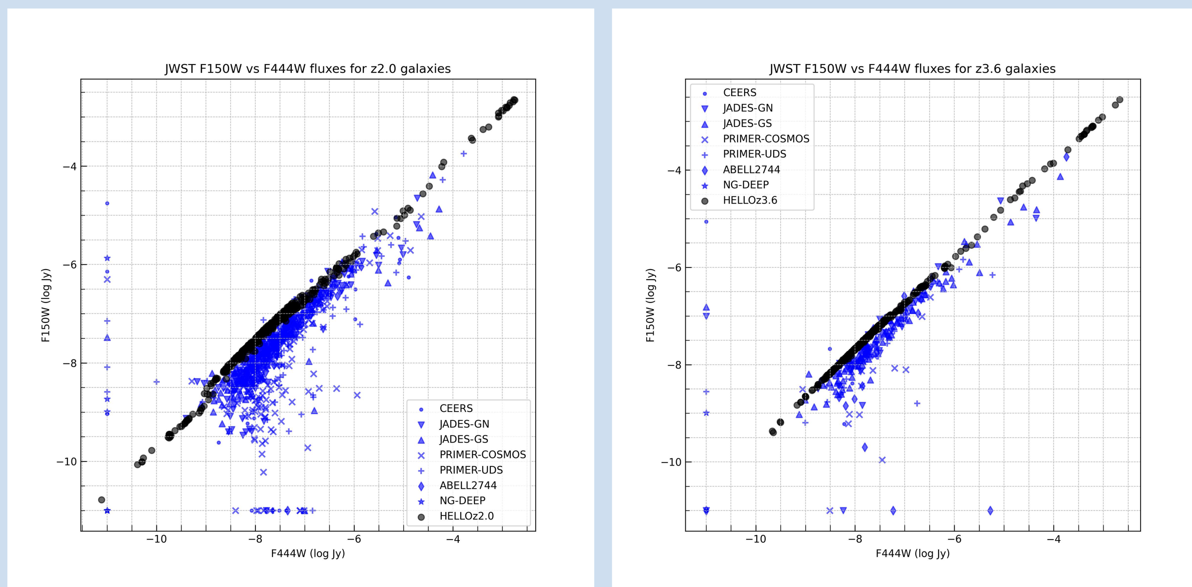

Fig. 4: *JWST NIRCam F115W vs F444W fluxes for ASTRODEEP-JWST galaxies (blue) and for HELLO simulated galaxies (black).*

UV fluxes and magnitudes vs M_*

⇒ Every HELLO galaxy is put through the SKIRT code after specifying a source field, radiation field, dust model, and JWST instrument parameters to give UV fluxes.

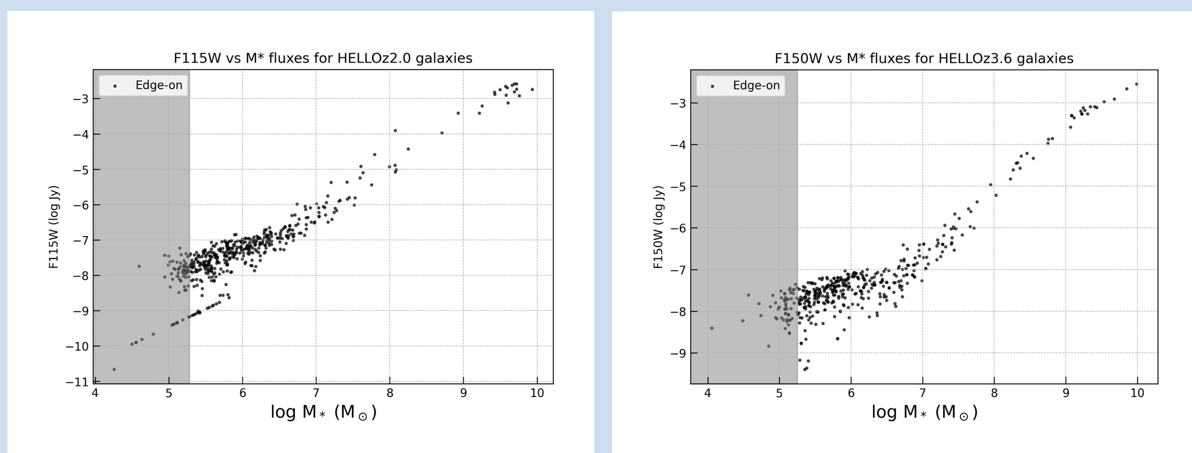

Fig. 5: *JWST NIRCam F115W (1.15 μm) and F150W (1.50 μm) fluxes vs M_*. Grey shaded region represents region beyond stellar resolution limit of HELLO.*

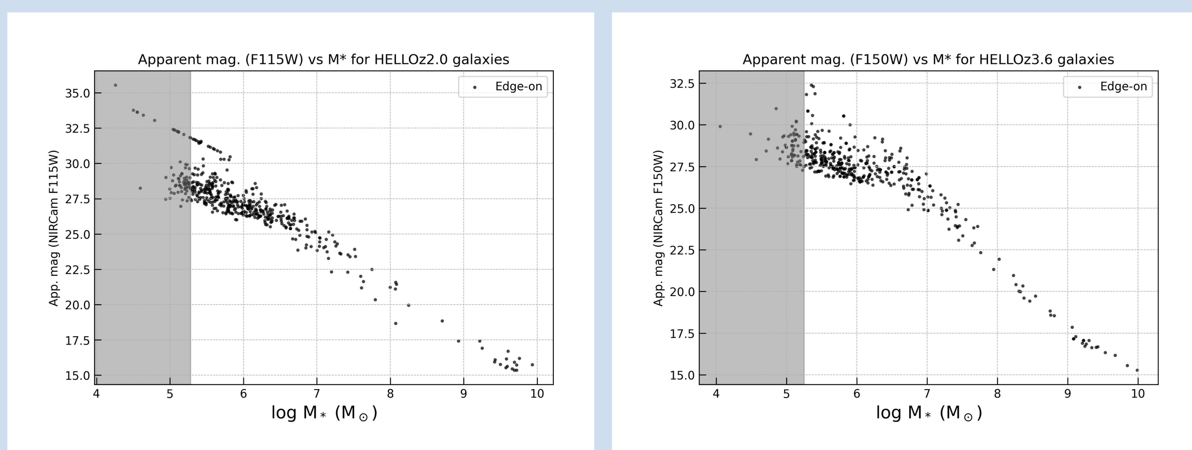

Fig. 6: *Fluxes from Fig. 5 converted to apparent magnitudes.*

What's next?

⇒ Obtain the **halo mass function (HMF)**.
⇒ Convolve **Fig. 6 with HMF** to obtain UV LF.
⇒ Employ an **updated young stellar library** model and quantify the changes in galaxy SEDs and colors.

Scan the QR code!

References

1. Waterval, S. et al. (2024); doi:10.1093/mnras/stae1913
2. Wang, L. et al. (2015); doi:10.1093/mnras/stv1937
3. Merlin, E. et al. (2024); doi:10.1051/0004-6361/202451409
4. Behroozi, P.S. et al. (2013); doi:10.1088/0004-637X/770/1/57
5. Moster, B.P. et al. (2013); doi:10.1093/mnras/sts261
6. Manzoni, G. et al. (2025); doi:10.48550/arXiv.2502.04702